Uncertainty and Organization Design

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Abstract

The task environment, characterized by the degree of complexity, variability, and routine of workers' tasks, creates varying degrees of asymmetric information between workers and their supervisors, as well as poses varying degrees of difficulty for supervisors and workers in making correct decisions. Thus the task environment generates *internal uncertainty*, some of which is under the control of workers, in contrast with *external uncertainty*, which arises from the market and is beyond their control. The measures that address problems associated with internal uncertainty (including incentives, delegation of decision-making to workers, monitoring by supervisors and internal labor markets) are elements of *organization design.* We explore theoretically and empirically the relationship between uncertainty and organization design, expanding on Baker and Jorgensen's (2003) idea that the risk-incentives relationship depends on the nature and sources of risk and Prendergast's (2002a) idea that incentive pay is not a direct response to a firm's task attributes but is part of a broader organization design that includes additional complementary and substitutable elements.

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I. Introduction

The twin desires to increase worker effort and have it directed more precisely towards organizational objectives have motivated countless attempts at reorganization and redesign of work in organizations. A large literature in economics has been devoted to measures that can elicit worker effort that is optimal relative to principals' objectives. The choice of such measures is the problem of organization design. Until fairly recently, organization design has been restricted to the choice of incentives, with a relatively simple prescription: when agent effort is costlessly observable the optimal design (contract) should consist of fixed wages, but in the presence of asymmetric information that favors agents, some sharing arrangement should be instituted. Workers' share of the results of their efforts should bear a negative relationship to the degree of uncertainty that affects the results but is beyond the control of workers.

In recent years, the economics literature on organization design has expanded considerably but the basic relationship between uncertainty and incentives remains central to the understanding of organization design, and the relationship between incentives and other elements of organization design remains little studied. Recent contributions by Baker and Jorgensen (2003) and Prendergast (2002a) provide new ideas and challenges on both points, and supply the motivation and the starting point of the present paper.

Prendergast (2002a) argues that there is asymmetric information between agent-workers and principal-managers that arises from the workers' task environment. The principal's limited information creates for her uncertainty regarding outcomes and induces her to renounce making some decisions by delegating them to her better-informed agents. In order to induce agents to make good decisions on her behalf, the principal provides them with financial incentives. Hence greater uncertainty leads to more delegation and therefore greater reliance on incentives. This positive correlation between risk and incentives contrasts with

standard agency theory's central prediction that greater uncertainty limits reliance on incentives so as not to impose too large risks on risk-averse agents.

Baker and Jorgensen (2003) attribute this "local and empirical ambiguity results to a failure to distinguish different types of uncertainty." External uncertainty (labeled by Baker and Jorgensen as "noise") arises from the market and other aspects of the external environment; it is the same for principals and their agents and is beyond the control of both parties, and therefore agents should not react to it and should not bear any risk associated with it. In contrast, asymmetric information between principals and agents associated with agents' specific knowledge may change their actions and creates strategic or internal uncertainty for principals ("volatility").

Incentives and decision-making delegation are two important elements of organization design but there are additional elements that complement or substitute for them. In particular, firms rely on monitoring of inputs and outputs to ensure that workers act correctly (e.g., Hart and Moore, 2005, Garicano, 2000), and on internal labor market practices to provide long-term incentives, accumulate firm-specific knowledge, aid in the collection of information about worker behavior, and contend with issues of *ex post* hold-up problems associated with various incentive contracts (e.g., MacLeod and Carmichael, 2000).

In this paper we build on and integrate previous contributions to develop a theoretical framework that regards organization design as a set of measures assembled to ameliorate various problems that may occur in organizations. We classify these problems as technical-administrative if they arise from bounded rationality and as agency-managerial if they stem from the pursuit of self-interest. We argue that depending upon the nature of informational problems, incentives will be used as a direct response to uncertainty (Baker and Jorgenson, 2003) or through the use of delegation of decision-making (Prendergast, 2002a). We further extend the argument in view of the substitution opportunities and complementarities with monitoring and internal labor market practices, two additional organizational design measures that have played a central role in economic analysis.

Organization design is an involved process whereby the principal selects a combination of complementary and substitutable practices that together direct and improve the effort of

workers in order to pursue organizational objectives given various constraints and contingencies. For example, even in a relatively simple operation such as a restaurant and focusing only on the wait staff, the manager has to choose how much discretion to permit the wait staff in terms of choices of items not on the menu; whether to have each table serviced by a single member of the wait staff or possibly more; whether to require waiters to pool tips and divide them equally among the waiters or allow individuals to keep the tips they earn; whether to have a staff meeting before the dinner crowd arrives to decide how to introduce specials or how to deal with particular clients; whether to allow waiters to explain to kitchen staff details of certain orders; how much to monitor the way orders are taken, food is brought to the table and so on; how much training to provide; whether to supply promotion opportunities, and more. There is no universally best way of making these choices: restaurant managers need to consider how complex is the menu, how complicated is the food preparation, how much flexibility the restaurant wants to provide to its clients, what is its desired level of service, and how predictable are the flow of diners and their food choices.

The choices of firms regarding the degree of delegation, monitoring, incentives and internal labor market practices in response to uncertainty and the interplay among these practices have been studied previously. Some studies have demonstrated a significant positive link between risk and delegation in the context of franchising (Lafontaine and Slade, 1991), significant positive link between delegation and incentives (MacLeod and Parent, 1999, Nagar, 2002), whereas others have examined the firm's choice between monitoring and pay suggesting that firms use pay (efficiency wage) as a substitute for monitoring (Neal 1993, Rebitzer 1995). Foss and Laursen (2005) and DeVaro and Kurtulus (2006) analyze the effect of uncertainty on the relationship between incentives and delegation of decision-making, and find positive correlations between risk and delegation and between delegation and incentives but only limited support for the instrumental role of delegation. Given the data restrictions and measurement issues that previous studies have faced, the empirical analyses in the extant literature are piecemeal and consider at most two elements of organization design, with limited ability to relate firms' choices to various contingencies.

Thanks to a uniquely rich dataset on a cross-section of 640 Minnesota-based firms we are able to explore many of the relationships we characterize theoretically. Our empirical analysis proceeds in two steps. First, we reexamine the relationship between risk and incentives by applying Baker and Jorgenson's and Prendergast's arguments about different sources of uncertainty and the instrumental role of delegation of decision-making to the employment relationship between shop-floor workers and their supervisors. Second, we extend these arguments to include a broader set of organization practices. Our dataset contains survey information on individual, group and firm-based performance-pay plans for shop-floor workers, on monitoring and internal labor market practices, as well as information on external uncertainty (measured as the volatility of income in a firm's industry) and internal uncertainty (measured as the complexity, variability and routine of front-line workers' tasks). We are therefore able to identify the differential relationship between external and internal sources of uncertainty and several types of incentive plans and other elements of organization design.

The results confirm the importance of the distinction suggested by Baker and Jorgensen between different types of risk depending on the type of informational issues faced by the firm as a whole, its supervisors and its workers. We find strong evidence of a negative relationship between external uncertainty and incentives linked to firm-level performance (profit sharing), but not between external uncertainty and individual incentives. The findings also highlight the crucial role played by delegation of decision-making. We find that decision-making delegation is significantly and positively linked to internal uncertainty and after delegation is controlled-for, individual-level incentives are effectively unrelated to internal uncertainty. The instrumental role of delegation in the risk-incentives trade-off predicted by Prendergast is empirically validated for individual and group-level incentives plans.

We also provide the first empirical evidence of relationships among additional organization design practices whose individual and combined importance, although widely discussed theoretically, has not been empirically validated within a single conceptual framework. We find that internal uncertainty (that is, shop-floor workers' task environment) influences substantially organization design through delegation of decision-making as well as

monitoring. There is also evidence of substitutability between firm-level incentives and monitoring and internal labor market practices.

The paper proceeds as follows. Section II outlines the theoretical framework. Section III describes the data and empirical strategy, and Section IV is devoted to a discussion of the results. Section V concludes the paper.

II. Theoretical Framework

The tradeoff between risk and incentives is a key element of the agency theory literature. In the basic agency model, risk is characterized by the addition of a random noise in the worker's effort-output function creating variability in output that cannot be uniquely attributed to the agent's effort. As a result, the use of incentives that link pay to output is hypothesized to decrease with an increase in the variance of the noise. Empirical tests of the negative relationship between risk and incentives have brought inconclusive results, calling for a reassessment of the theory.[1]

Baker and Jorgensen (2003) extend the definition of risk by introducing uncertainty that affects the agent's optimal choice of effort, which they call volatility, in addition to a random noise affecting output. Prendergast (2002a) adds delegation of decision-making to the set of possible decisions available to a firm that faces risk; risk arises from informational problems associated with agents work environment.

In this section we develop a framework that integrates these studies' insights about risk and uncertainty and organization-design responses in the form of incentives and delegation. We emphasize the market and the task environments as the sources of differing degrees of incomplete and asymmetric information and of varying demands on workers' and supervisors' skills, knowledge and abilities, which generate various problems that affect a firm's success in pursuit of its goals. These problems can be countered by incentives and delegation of decision-making, as well as additional elements of organization design. We focus our theoretical and empirical analysis on the shop-floor level and concentrate on the relationship between core workers and their supervisors, rather than deal with the complexities of design of the entire

[1] See Prendergast (2002a) and De Varo and Kurtulus (2006) for a review of the evidence.

organization. Core workers may work on an assembly line, be cashiers and vendors in a retail establishment or tellers in a bank and waiters in a restaurant; software engineers are core workers in a software-development company as are professors at a university.[2]

What Drives Organization Design? Agency-Managerial and Technical-Administrative Problems, External and Internal Uncertainty

The design questions that a restaurant manager has to answer are similar to those that managers in other settings must address: should employees be paid only fixed wages or a combination of fixed pay and incentives, should supervisors assign narrowly-defined tasks to their subordinates or instead delegate to them some rights and responsibilities to decide how and when the work should be done, how much supervisors should monitor employees and whether or not an internal labor market should be established. The design is aimed to get employees to work effectively towards the goals of the organization by addressing two major types of problems: those that stem from insufficient knowledge, skills or abilities required to carry out certain tasks, and those that arise from the pursuit of self-interest. The first type of problems, emphasized by 'team-theory' and 'bounded-rationality' economists, may be termed *technical-administrative (TA) problems*, whereas the second type, the hallmark of agency theory, may be called *agency-managerial (AM) problems*.[3]

Were workers perfectly skilled and knowledgeable relative to the requirements of their jobs, and assuming away any AM problems, the organization design problem would have been simple: the head of the organization would ask for information that would be promptly, costlessly and flawlessly supplied, would solve the maximization problem for the firm, and then would send specific instructions for execution in the rest of the organization, including shop-floor workers. No supervisors, no monitoring, and no incentives would be needed, because everything would flow just as the head of the organization had wanted. Workers would be paid fixed wages set at a level just sufficient to attract them to the firm. However, this is obviously not the case in any realistic setting. To varying degrees, workers make good

[2] Throughout the paper we use the terms core employees, core workers, and shop-floor workers and employees interchangeably. Osterman (1994) discusses the concept of core employees in detail.
[3] This terminology is used by Ben-Ner, Montias and Neuberger (1993).

but imperfect decisions; they gather, interpret, summarize and transmit some but not all useful information; and they misinterpret some information and make erroneous decisions – all *manifestations of* ***TA problems***.

Were workers perfectly obedient subordinates of their superiors, that is, perfect agents who do what they are told, no more and no less, and assuming away any TA problems, the organization design problem would have again been simple: the head of the organization would announce a set of tasks for all workers, and they would just follow instructions; no incentives, monitoring and other familiar practices would be required. Few if any real-life organizations have this sort of workers. To various extents, workers work less hard than they can, they choose, when they can, to carry out tasks that are more agreeable to them by way of effort or interest, and make choices that sometimes favor them at the expense of what they know is best for the rest of the firm – all *manifestations of* ***AM problems***.

Organization design aims at getting employees to do well what principals want; this is equivalent to amelioration of *potential* TA and AM problems. Our interest is in those elements of organization design that affect the behavior of core employees, the shop-floor level workers, who are the focus of our empirical analysis. Core employees are agents to a supervisor who is a quasi-principal on behalf of higher-level management. At this level, organization design consists principally of the choice of the degrees of: 1) the addition of incentives to fixed wages; 2) the delegation of decision-making responsibilities to workers vs. supervisors; 3) the monitoring of workers by their supervisors; and 4) the offering of promotion and training opportunities as elements of internal labor markets.[4]

Our analysis rests on conventional assumptions: workers are risk averse, have limited skills, knowledge and abilities, and are willing to pursue their own interests if an opportunity presents itself. We treat supervisors as quasi-principals, and disregard the TA and AM problems arising from their relationship with higher-level management and firm owners.

[4] There exist additional elements such as employee recruiting and selection that will not be addressed in this paper. Our aim is to incorporate in the analysis of organization design key elements that figure prominently in the economic literature as well as in practice.

We now turn to examine how the external and internal environments in a firm create uncertainty and generate AM and TA problems, and then continue with an analysis of how application of elements of organizational design can reduce the extent of these problems.

External uncertainty, noise in Baker and Jorgensen's (2003) language, stems from sources that are not under the control of the unit under consideration. At the shop-floor level external uncertainty regards the level of future demand for shop-floor activities and is generated by the market or other units that interact with the shop floor; it is the same for workers and their supervisors. The impact of external uncertainty on incentives is predicted well by agency theory: the greater the uncertainty the less likely it is that a firm will offer its risk-averse core employees incentives linked to the sources of uncertainty that are not controllable by workers at the shop-floor.

Internal uncertainty arises from the task environment at the workplace. We argue that internal uncertainty (a) is an increasing function of the difficulty of the task environment, (b) creates AM and TA problems at the shop-floor level, and (c) affects differentially workers and supervisors. We explain below how these assumptions matter for understanding the differential effects of uncertainty defined by the task environment on organization design.

The severity of potential TA and AM problems, given a particular workforce, is affected by factors that place demands on workers' and supervisors' skills and abilities, and factors that afford workers opportunities to pursue their self-interest. These two overlapping set of factors are grounded in workers' jobs. Jobs are designed for efficiency relative to organizations' business strategy, technology, workforce, and labor and product market conditions (Zoghi, Levenson, and Gibbs, 2005, Lindbeck and Snower, 2000). A job consists of a series of tasks that a worker has to execute. The jobs thus define the task environment and determine the severity of TA and AM problems.

A characterization of tasks that is particularly relevant to the understanding of TA and AM problems considers how simple or complex, stable or variable, and routine or non-routine tasks are.[5] These three task attributes affect workers' ability to make good decisions, the

[5] See Perrow (1986), Grandori (1991), March and Simon (1993), Autor, Levy and Murnane (2003) and Manning (2005) for related discussions of task attributes. The terminology used here is patterned after that used by Perrow (1986).

information workers have about the association between their efforts and results, and the information supervisors have about what workers do and how hard they work.

Task complexity. The execution of complex tasks requires more skillful, thoughtful and experienced decision-making, and is more prone to errors than the execution of simple tasks. For example, the task of solving a system of nonlinear equations is more complex than the task of solving for x in $3x=6$; the task of extracting a tumor from a brain cavity is more complex than the task of extracting a splinter from a finger; the task of serving a customer in a fast-food restaurant is simpler than the task of serving a demanding customer in an expensive restaurant; and the task of writing a report about local crime statistics is simpler than the task of analyzing the reasons for changes in the incidence of local crimes.

Task complexity affects the information sets of both workers and their supervisors. The worker who carries out a complex task is in a better position than a supervisor to determine the specific demands of a particular situation. The worker has better information about the complex circumstances of his job and what may be the best course of action than the supervisor does. The worker could, in principle, transmit his information to the supervisor so that she could make the key decisions for the worker, but the lack of reliability of transmission of information increases with the complexity of the worker's tasks.[6] Supervisors' incomplete information is a TA problem that may lead, as we discuss later, to possible delegation of decision-making power from the supervisor to the shop floor worker. Although the worker has better information than the supervisor, he too suffers from incomplete information regarding the possible outcomes of his actions, and the uncertainty of outcomes is likely to increase with the complexity of the worker's tasks. This is a TA problem faced by the worker.

The execution of complex tasks creates also a classic asymmetric information situation whereby the worker knows better than the supervisor what and how various factors (such as the multifaceted efforts of the worker and of other workers and managers, equipment, the quality of materials) combine to determine the outcome of the execution of the task. Asymmetric information creates opportunities for the emergence of standard AM problems.

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[6] The problem with reliable transmission of information is twofold. First, because of the complexity of the situation at the shop floor the information is difficult to formulate, transmit and then decipher (Marshack and Radner, 1974). Second, because workers have incentives to portray information in ways favoring their interests, supervisors will not trust the information because they cannot verify it.

Task variability. Workers' tasks may remain unchanged for certain periods of time, as is the case of an assembly line where a worker installs windows for several hours, or may be moderately variable in the case of a bank teller who works with patrons with different needs, and even more variable for a general dentist. The greater the variability of a task the more careful, skilled and experienced a worker must be in order to execute the task faithfully, and the less effectively can a supervisor observe the quality of the execution of different dimensions of the task (unless more time is invested in monitoring). The effects of task variability on AM and TA problems and on uncertainty for the worker are similar to those of task complexity.

Task routine. Routine reflects the incidence of exceptions in the execution of tasks. The tasks of an assembly line worker, bank teller and general dentist are routine (although they differ in the degrees of complexity and variability), whereas the tasks of a researcher and of a developer of new electronic games are non-routine. Routine tasks are easier to execute and are easier to observe by a supervisor than non-routine tasks. Given other task attributes, the less routine a task is, the more severe will be the AM and TA problems.

The foregoing discussion suggests that the more complex, variable and non-routine are the tasks of front-line workers the more severe and difficult will be the TA and AM problems. Henceforth we will refer to the *difficulty of the task environment* as a way to capture the combined effect of more complex, variable and non-routine tasks. In the empirical work reported in the next section, we measure the difficulty of the task environment as the sum of the scores (on a 1-5 scale) of complexity, variability, and non-routine. The arguments we made above in our discussion of complexity apply also to the broader concept of task environment. A more difficult task environment creates greater TA problems for supervisors, greater TA problems for workers and more difficult AM problems between supervisors and workers. In the remainder of this section we describe the organization design responses to each type of problem focusing on incentives first and then considering additional organizational design choices like delegation, monitoring and internal labor market practices which may complement or substitute for incentives.

Organization Design Responses to Internal and External Uncertainty

The task environment generates AM problems through the asymmetric information it creates, because the more difficult the task environment, the fewer the opportunities for supervisors to observe costlessly workers' efforts. The organization-design response to AM problems related to asymmetric-information consists of incentives that better align workers' interests with those of the organization – the standard solution from agency theory. This argument is similar to Baker and Jorgenson (2003)'s argument about the positive effect of volatility on incentives. Thus the likelihood of reliance on incentives and their strength increases with the degree of internal uncertainty about the valuable information regarding how to do the job that workers possess but supervisors do not.

A difficult task environment can also generate TA problems for the workers and reduce their control over outcomes. If workers are risk averse, then the resulting uncertainty for them will increase the firm's cost of incentives and therefore lower the likelihood that they will be offered. Generally, uncertainty – whether external, arising from the market and other units in the organization, or internal, stemming from workers' TA problems – impacts controllability by workers and therefore incentives should be used less to motivate risk-averse workers.

In addition, the difficulty of the task environment impacts supervisors' ability to make informed decisions about how shop-floor workers should carry out their activities. This is a TA problem for supervisors, who can alleviate it by transferring some decisions to the better-informed workers. However, delegation of decision-making power creates additional asymmetric information between workers and supervisors and generates opportunities for workers to pursue their interests at the expense of the organization; hence delegation creates an AM problem. In order to contend with this problem, workers are offered incentives that better align their interests with those of the organization and induce them to make decisions in the interests of the organization. This is Prendergast's (2002a) argument about the effect of task complexity on delegation and incentives (see also Ben-Ner and Jones, 1995).

Relating the discussion above to the debate on the existence of a risk-incentives trade-off, the overall effect of uncertainty on incentives is ambiguous because (1) it depends on the relative importance of TA and AM problems which create opposite responses in terms of

incentives as the difficulty of the task environment increases and (2) as internal uncertainty induces delegation which in turn calls for the use of incentives (Prendergast, 2002a), there may be no empirical link between internal uncertainty and incentives after the choice of delegation has been accounted. We further discuss these issues in the empirical section.

The foregoing discussion referred implicitly to delegation and incentives at the *individual worker level*. Decision-making may also be delegated to teams of workers, and team decision-making requires team-level incentives. Delegation to teams and other groups of workers rather than to individual workers is favored when group cooperation and concerted effort are particularly important, such as when there is substantial reciprocal interdependence in the tasks of employees. In the empirical section we analyze the role of uncertainty separately for individual, team and firm level practices. We expect the previous analysis to apply similarly to individual and team-level incentives and decision-making delegation. We conjecture that the negative effect of external uncertainty will be stronger for team and firm-level incentives than for individual incentives because of the more direct exposure of the former type of incentives to the market.

Incentives and delegation of decision-making are central but not sole elements of organization design. Limitations to reliance on incentives associated with risk, dysfunctional behavior, cost and more, require the implementation of additional practices to substitute for incentives or complement them to make them more effective (Milgrom and Roberts, 1995, and Prendergast, 1999). Monitoring and internal labor markets are familiar design elements that have been studied extensively by economists.

Monitoring refers to the collection of information about signals of worker effort. It may be exercised continuously or at fixed or random intervals, and may be carried out by direct supervisors, coworkers, others with whom a worker has periodic or occasional contact (such as customers and trainers), or equipment (such as keyboard stroke counters and surveillance cameras). Monitoring may complement or substitute for incentives. On the one hand, the "monitoring-intensity" principle states that improving information gathering through monitoring can be profitable in situations where incentive intensity is high and therefore information is more valuable (Milgrom and Roberts 1992). On the other hand, the efficiency-

wage literature considers the incentives-monitoring relationship as a tradeoff: if the cost of the extra pay needed to compensate risk-averse individuals to bear risk associated with incentives is higher than the cost of monitoring, then monitoring will be used as an alternative to incentives. The extent to which these two elements of organization design will be used as complements or substitutes in a particular situation depends on their relative (marginal) costs.[7]

In some task environments information about various signals of worker effort can be collected over long periods of time through practices associated with *internal labor markets (ILM)*. Such information collection does not constitute direct monitoring although has a similar function and may be a co-product of an activity that has additional purposes. For instance, promotion-from-within is based on accumulation of evidence and testimonies about workers' performance, behaviors and disposition over periods of years; on-the-job training, in addition to imparting skills and knowledge, provides an opportunity for trainers to assess workers' abilities and knowledge in controlled settings.[8] These and other ILM practices may be used in task environments where monitoring is particularly difficult or costly and where incentives are very expensive or difficult to administer because of unobservability of individual output.[9] ILM practices such as promotion-from-within constitute also long-term incentives, so they may partially substitute for short-term incentives.

The foregoing theoretical discussion is summarized in Figure 1. To summarize, organization design at the shop-floor level is crafted in view of internal uncertainty, which is determined by the nature of the task environment associated with core workers' jobs. The direction of the effects of the task environment on individual elements of organization design is contingent on the specific nature of the substitution and complementarity relationships among them. We can predict unambiguously that internal uncertainty increases reliance on delegation

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[7] For example Demougin and Fluet (2001) show that the extent of complementarity or substitution effects between incentives and monitoring depends on the level of informational rent or workers liability limit (the agent's ability to post a bond or the principal's ability to levy a fine), and monitoring characteristics (the cost of increasing the precision of information and the required effort level). The relative cost of monitoring may also be affected by uncertainty; Prendergast (2002b) shows that in presence of supervisor favoritism, greater environmental uncertainty leads firms to rely more on incentives and less on monitoring.

[8] See, for example, Milgrom and Roberts (1992, ch. 11) and Baron and Kreps (2000) for a discussion of the various effects of internal labor markets, including improved observability.

[9] For a model of this argument in the context of academic tenure as internal labor markets, see Chen (2005). In a related fashion, Carmichael (1988) argues that tenure is needed to induce professors to provide specialized information that is not available to administrators.

of decision-making. The net effect of internal uncertainty on incentives depends on the specific magnitude of effects that have opposite signs (see rows A, B and E). Monitoring and internal labor markets will also be affected by uncertainty and delegation through their link to incentives decisions; the direction of the effect is theoretically indeterminate because it depends on the net effect of internal uncertainty on incentives and on the substitution or complementarity relationship between these practices and incentives and among themselves.[10]

III. Data and Method of Analysis

Description of the Dataset

Our sample is drawn from the *Minnesota Human Resources Management Practices Survey*. The survey was administered from 1994 to 1996 to 2,021 private for-profit Minnesota-based firms with at least 20 employees, representing a broad spectrum of industries. In order to ensure representation of diverse industries, ownership forms and firm sizes a stratified sampling strategy was employed. The overall response rate was 43% (874 surveys). The survey questionnaire asked respondents about individual, group and firm-level incentives, various human resource practices such as training, the degree of employee participation in decision making, the nature of the tasks carried out by shop-floor employees, and other aspects of firm organization. Many of the questions focused on *shop-floor or core employees*, the largest group of non-supervisory, non-managerial employees who are directly involved in making the product or providing the service, such as assembly-line workers at an auto manufacturing factory, computer programmers in a software company, or sales representatives in an insurance company (Osterman, 1994). Most of the variables employed in our analyses are derived from responses to the survey.[11]

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[10] More precise predictions about such relationships would require further assumptions about the firm and its environment which is beyond the scope of this paper. Our objective at this point is to emphasize their equal importance with delegation of decision-making for assessing the impact of uncertainty on incentives. We treat and later analyze the direction of such effects and related conclusions on complementarities and substitutions as empirical questions.

[11] The survey is available at http://webpages.csom.umn.edu/hrir/abenner/web/papers/work-surv/work-surv-01.pdf. The administration of the survey was supported by grants from the Center for Urban and Regional Affairs at the University of Minnesota and the Sloan Foundation. It was administered in two stages in order to economize on staff required to handle the work. The first stage included nearly 600 firms (all Minnesota publicly-traded firms

Additional variables were constructed from the COMPUSTAT dataset for publicly traded firms (industry-level external uncertainty and capital-labor ratio), and Minnesota Department of Economic Security (number of employees and wage bill in sample firms). These data were merged with the survey data. The working sample, after deleting very large firms, firms that did not meet inclusion criteria (especially minimum size) and firms with missing information, consists of 640 firms

Variables

Appendix Table 1 provides variable definitions, sources and descriptive statistics. The key variables concerning environmental uncertainty are constructed as follows. External uncertainty is measured by the standard deviation of the net income in the firm's 3-digit SIC industry over the period 1990-1994 (the five years preceding the survey). This measure is one of the several measures proposed in the literature for the purpose of measurement of risk, most of which are correlated due to the fact that they tap into various aspects of variability over time in profitability (see, for example, Bromiley and Miller, 1990, and Ruefli, Collins and Lacugna, 1999, for reviews).[12]

The internal uncertainty variable is constructed as the sum of the degree of complexity, variability and (reverse coding of) routine attributes of the tasks carried out by shop-floor workers. Prendergast (2002a) identifies job complexity as an important dimension of environmental uncertainty creating the need for delegation; task complexity is one component of our internal uncertainty measure, and it turns out that results are very similar when using either measure.[13]

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and firms that were known to have employee stock ownership plans). The second stage included 1,500 firms (all retail food firms and a representative sample of 958 firms from all industries excluding agriculture). In the second stage a few questions were added to the survey, including monitoring of core employees by their direct supervisors; analyses in Tables 3a and 3b, which utilize the monitoring variable, rely on about half as many observations as Tables 1 and 2a and 2b. See the text for details.

[12] An empirical measure of external uncertainty that affects specifically the shop floor in unavailable. As discussed in section II, market noise reflects an important component of external uncertainty for the shop floor, and it is likely that noise originating in other organization units that interact with the shop floor is correlated with market noise.

[13] Results based on task complexity alone as measure of internal uncertainty are available upon request.

The organization design variables concern incentives, delegation of decision-making, monitoring, and internal labor market practices. Where data are available, we make distinctions between individual, group and firm level variables. Regarding incentives, we use survey data to distinguish the existence of individual incentive plans, group-level incentives (group bonus), and firm-level incentives (profit sharing, which include cash and deferred profit sharing plans).[14]

Delegation of decision-making to individual workers is described by two alternative variables, one concerning the degree of shop-floor employees' participation in employee involvement programs and the other regarding the level of control these workers have over how their jobs are done. These variables capture related but different aspects of delegation of decision-making responsibilities and therefore we include them separately in the analysis. Delegation of decision-making to groups is captured through a dummy indicating whether or not the firm uses self-managed teams.

Monitoring is captured by a single item that measures (on a scale of 1-5) the degree to which core employees' work is monitored by supervisors. We create an index of internal labor market practices based on the sum of dummies indicating reliance on promotion from within, employment security, on-the-job training, and the presence of training in team building skills for team work.

To control for key firm characteristics, all estimations include the firm's industry (one-digit SIC code), size (number of employees), age of the firm, whether it is unionized and the capital-labor ratio of the firm's 3-digit SIC code industry. The capital-labor ratio is a proxy for firm technology, which, in addition to industry, may affect the decision to use performance-based plans and other practices.

Empirical Strategy

The empirical framework follows from the discrete nature of the organizational design variables we use to study firm optimal decisions. We assume that firms have reached equilibrium and operate at their optimum in terms of the combination of organization design

[14] These plans, when offered, may be available also to workers other than shop-floor employees.

practices they chose given the level of (exogenous) uncertainty they face. We do not evaluate the consequences of their decisions but explore and test whether their organization design decisions conform to the theoretical arguments illustrating the relationships between uncertainty and organizational design.

We use estimation frameworks that define the likelihood of choosing incentives alone (Baker and Jorgensen's argument), the likelihood of choosing a mix of incentives and delegation (Prendergast's argument), or the likelihood of choosing a combination of incentives, delegation, monitoring and internal labor market practices.

In particular, for an analysis of the various sources of uncertainty (internal and external) and their effect on incentives including a test of Baker and Jorgensen's predictions, we use a linear probability model for the likelihood of choosing incentives.[15]

We consider the following regression:

Model A – Baker and Jorgensen

(1) $Prob(Incentives) = f(X, EU, IU, \varepsilon_1)$

where ***X*** corresponds to firm characteristics, ***EU*** stands for external uncertainty and ***IU*** for internal uncertainty. External uncertainty is expected to be negatively associated with the likelihood of using incentives. The effect of internal uncertainty (the task environment) on incentives is ambiguous, depending on the weight of AM problems that it creates (which increases the use of incentives) relative to TA problems it engenders (which reduces incentives). The sign of the coefficient associated with internal uncertainty should reflect which effect dominates the other. On the other hand, as mentioned in the theoretical discussion, a positive relationship between internal uncertainty and incentives may be the

[15] We use the linear probability model over the logit or probit models for ease of interpretation of the coefficients as marginal effects. A drawback of the linear probability model is that it does not take into account that the dependent variable is binary and can therefore yield predicted values outside the unit interval. This problem is serious when the mean of the dependent variable is close to either 0 or 1 (Maddala, 1983). In our sample, the frequency of incentive plans are 33.6%, 23.2%, 36.4% for individual, team and profit sharing plans respectively. This is reasonably far from the lower and upper bounds of the unit interval. In fact, none of the predicted values of the variables lies outside of the unit interval except for those associated with the likelihood of group bonus but it is only a small percentage (1%).

result of failing to control for the instrumental and complementary role of delegation. We next consider that possibility by analyzing the role of uncertainty on the joint decision to delegate decision-making and provide incentives.

For an analysis of firm multiple decisions including a test of Prendergast's predictions about risk, incentives and delegation, we use simultaneous equations models. A simultaneous equations model is appropriate in this case because both incentives and other organizational design practices are likely to be affected by common unobservable factors. In particular, for Prendergast's predictions about the relationships between uncertainty, incentives and delegation, we define the following empirical model:

Model B - Prendergast

(1) Prob(Delegation) = g(X, Z, IU, e_1)

(2) Prob(Incentives) = f(X, Delegation, e_2)

where (e_1, e_2) is bivariate normal N(0, Σ)[16] and ***X*** reflects firm characteristics. Equation (1) states that delegation is directly affected by internal uncertainty (***IU***); we expect a positive association between the two variables. Similarly, we expect in equation (2) a positive association between delegation and incentives to capture the complementary relationship between the two practices.

For identification of the model, ***Z*** includes a variable that affects the choice of delegation but not of incentives; the variable is a participation index computed as the sum of the values for each of the items that measure employee participation in decision-making on various issues.[17]

Prendergast (2002a)'s main argument is that the positive relationship found in the empirical literature on the risk-incentives relationship may be a result of failure to control for

[16] The variance-covariance matrix Σ is non-diagonal as we assume correlation in the disturbance terms across equations.

[17] The information comes from a survey question (on a scale of 1 to 5): "To what extent do employees participate in the following issues?" and the issues listed that we select are work rules, working conditions, selection of personnel, training and development, social events, job redesign, safety and health, equipment maintenance, selection of materials, selection of new equipment, investment policies, production planning, and corporate finance. We find the correlations between this measure and incentives to be very low for all the incentives plans.

the firm's decision to delegate more responsibility in the presence of internal uncertainty (Prendergast 2002a, p. 1097). As a result, internal uncertainty should have no effect on incentives once delegation has been taken into account. We evaluate this statement by testing for the effect of internal uncertainty (***IU***) on incentives in the following augmented specification in which ***IU*** has been added to equation (2) in the previous model B:

Model C - Prendergast

(1) Prob(Delegation) = g(X, Z, IU, e_1)

(2) Prob(Incentives) = f(X, Delegation, IU, e_2)

Next we consider a more general model of the effect of uncertainty on incentives and other organization design practices. First, we integrate Baker and Jorgenson's (2003) predictions about uncertainty and incentives by including external uncertainty to the incentives equation (2) of model C. Second, we reflect the substitution/complementarity relationships between incentives and other organization design elements by including internal labor market and monitoring variables in the incentives equation.

Our analysis of the substitution/complementarity relationships between incentives and other organizational design practices is based on the following reasoning. Worker effort is extracted through organization design. We can think of effort being produced by incentives, monitoring and internal labor market as inputs; this is analogous to a production function framework in which output is produced by labor and capital and is in the spirit of Demougin and Fluet's (2001) model of the incentives-monitoring relationship. Since effort is unobservable we use instead the firm's average wage, which in a competitive market should be highly correlated with the firm's average effort. Instead of estimating a production function, we estimate the relationship among incentives, monitoring and internal labor market practices controlling for effort (wage).[18] The estimated parameters reflect correlations among elements of organization design and may give an indication of the substitution (negative coefficient) or

[18] This is analogous to estimating the relationship between labor and capital along an isoquant by controlling for the level of output.

complementarity (positive coefficient) of the given practice with incentives.[19] The model is formally described below:

Model D

(1) $Prob(Delegation) = g(X, Z, IU, u_1)$

(2) $Prob(Monitoring) = h(X, Q, IU, Delegation, u_2)$

(3) $Prob(ILM) = j((X, R, IU, Delegation, Monitoring, u_3)$

(4) $Prob(Incentives) = f(X, EU, IU, Delegation, Monitoring, ILM, Wage, u_4)$

where (u_1, u_2, u_3, u_4) is quadrivariate normal N(0, Σ')[20], $\boldsymbol{X}$ reflects firm characteristics and $\boldsymbol{Z}$, $\boldsymbol{Q}$ and $\boldsymbol{R}$ contain variables that directly affect delegation, monitoring and internal labor market practices, respectively, but not the decision to provide incentives.[21]

The model is built in a hierarchical fashion as we extend Prendergast's argument, with delegation being the primary variable that is affected by the task environment, followed by an equation reflecting the relationships between monitoring and delegation, then another equation for the relationships between the index of internal labor market practices and delegation and monitoring and finally an equation summarizing the relationships between all these and incentives. The one common variable across equations is internal uncertainty for which we test whether it affects not only delegation but the other organizational design practices. Figure 2 summarizes the empirical relationships we estimate.

Whereas we have advanced reasons for the specification of the incentives equation, the specification of the equations that determine monitoring and ILM could be reversed.[22] We find

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[19] Correlations among organizational design practices may be caused by firms' unobserved heterogeneity (Athey and Stern, 1998). The cross-sectional nature of our dataset does not permit treatment of firm-specific effects. Given our focus on firms' choice of organizational design, this is less of an issue than for analysis in which the outcome variable is firm performance. On the other hand, the present estimation framework assumes that uncertainty is exogenous but it may be correlated with unobserved firm heterogeneity. If a correlation exists, it is likely to be positive as higher type firms (with higher managerial ability) may be better equipped for facing greater external and internal uncertainty. This correlation would create an upward bias in our estimates of uncertainty effects. As a rough check we computed the correlation between firm size (a proxy for unobserved managerial ability) and both of our measures of uncertainty and found no significant correlation.

[20] The matrix of variance-covariance Σ' is non-diagonal assuming correlation in the disturbance terms across equations.

[21] For $\boldsymbol{Q}$ we use the number of employees per supervisor and for $\boldsymbol{R}$ we use a variable on the extent (on a scale of 1 to 5) of employee participation in the issue of personnel training and development.

that changing the order of the monitoring and ILM equations did not change our results. We further discuss this point in the results section.

We use three-stage least squares to estimate all simultaneous equation models in order to account for the endogeneity of organizational design decisions and the presence of common unobservable factors.[23] Although this method does not permit identification of causal effects, it is informative of whether uncertainty measures and organizational design practices are correlated with each other.

IV. Results

The results are presented in three sets of tables in the same order as the arguments in the theoretical and the empirical strategy sections. The analysis concerns (a) two levels of delegation of decision-making – individual and team – and uses two alternative individual delegation measures, participation and control, and (b) three levels of incentives (individual, group and firm). In order to streamline the presentation we present results based on delegation in terms of control in the Appendix. The main sample has 640 firms, but because not all firms were asked the monitoring question and because there are missing observations in the wage variable, the sample for the most general analysis presented in Tables 3a-3b concerns 305 observations. The last part of the analysis is devoted to robustness checks for the possibility of biases in the estimates due to such differences in sample size as well as checks for alternative specifications of model D.

The Risk-Incentives Relationship on the Shop Floor

Table 1 presents results for Model A, which tests Baker and Jorgensen's (2003) hypotheses. As conjectured, external uncertainty has a negative effect on the provision of incentives. The impact is strong for firm-level incentive plans and weak and insignificant for

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[22] The alternative model is defined as follows:
(1) Prob(Delegation) = g(X, Z, IU, u_1)
(2) Prob(ILM) = h(X, Q, IU, Delegation, u_2)
(3) Prob(Monitoring) = j((X, R, IU, Delegation, ILM , u_3)
(4) Prob(Incentives) = f(X, EU, IU, Delegation, Monitoring, ILM, Wage, u_4)

[23] This method also allows comparability of the coefficients with model A, which is estimated with a linear probability model.

individual and group-level incentive plans for shop-floor workers. In contrast, internal uncertainty has a significant positive effect on the likelihood of using individual and group incentive plans and no significant effect for the firm-level plan.[24] The positive effect suggests that the benefit of reducing AM problems through incentives exceeds the cost of compensating workers for bearing risk arising from TA problems (i.e., the balance of effects in rows A and B in Figure 1 is positive). This effect may also result from the instrumental role of delegation, that is, incentives picking up the effect of internal uncertainty on delegation. Note also that the R^2's in Table 1 are very low, indicating a poor fit of the incentives equation with the data. This reflects the limitations of a single equation model and the importance of integrating other organization-design practices for the understanding of firm decisions to provide incentives. We address this possibility by estimating models B and C. The results are presented in Tables 2a and 2b.

Results from simultaneous estimations of equations (1) and (2) of model B are presented in the left panel of Table 2a for individual incentives and the left panel of Table 2b for group (upper part of panel) and firm-level incentives (lower part of panel). As conjectured, internal uncertainty is associated with higher likelihood of delegation of decision-making at both the individual and group levels, and delegation is positively correlated with all incentives plans.

The right panel presents results for Model C, testing Prendergast (2002a)'s main conjecture on the instrumental role of delegation. For group bonus, there is indeed no significant effect of internal uncertainty on incentives. For individual-level incentives, there is still a positive effect of uncertainty on incentives but much reduced in comparison to Table 1 (0.018 versus 0.031) and only marginally significant. When control instead of participation is used as a measure of delegation (Appendix Table B1), the effect of internal uncertainty on

[24] The reverse order of effects of the two types of uncertainty on individual, group and firm-level incentives is not surprising. The external uncertainty measure reflects the external market, which affects directly firm performance and profit sharing but much less individual and group performance at the shop-floor level and the incentives linked to them, whereas the internal uncertainty measure reflects the task environment, which affects directly individual and group-level outcomes and only indirectly firm-level outcomes.

individual incentives becomes statistically insignificant. Overall, the results in Tables 2a and 2b for individual-level incentives and group bonuses are consistent with Prendergast (2002a).

For profit sharing, we find that internal uncertainty significantly reduces the use of incentives after controlling for team delegation. This result might be due in part to internal uncertainty picking up effects related to external uncertainty not included in the regression. Another explanation might be that in response to greater internal uncertainty, firms may use other organizational design practices such as monitoring and ILM practices, which may substitute for incentives and therefore not taking such practices into account leads to finding such negative relationship. These explanations can be tested by estimating the more general model D in which external uncertainty, monitoring and ILM practices are taken into account.

Additional Organization Design Responses to Uncertainty on the Shop Floor

Tables 3a and 3b (individual-level incentives and group and firm-level incentives, respectively) present a more comprehensive approach to the relationship among the two types of uncertainty and organization design, with simultaneous equations estimation of delegation, monitoring, internal labor markets, and incentives. We continue to use participation as the measure of delegation of decision-making at the individual level; results using control as the measure of delegation are presented in Appendix Table B2.

Consistent with the single-equation findings in Table 1, the results in both Tables 3a and 3b indicate that external uncertainty has no significant effect on individual or group-level incentives but significantly reduces the likelihood of using profit sharing plans. The effect of internal uncertainty on delegation is also similar to the effect estimated in Tables 2a and 2b.

The effect of internal uncertainty on incentives is now clearly small and not significant for both individual and group incentives. However, despite the addition of controls for external uncertainty and other organizational design practices internal uncertainty continues to be associated negatively and significantly with the likelihood of using profit sharing plans. A possible interpretation for this result is that the cost of workers' bearing risk from internal uncertainty arising from TA problems rises faster as uncertainty increases than the benefit of reducing AM problems through the use of firm-level incentives.

Based on the previous results, the relationship between internal uncertainty and incentives thus depends on the nature of incentives. In the case of individual and group-level incentive plans, performance is closely tied to workers' actions and there is a strong "line of sight", greater internal uncertainty is associated with a higher likelihood of using delegation and incentives to complement it. For firm-level incentive plans there is a weak "line of sight" and performance measures are not directly linked to workers' actions, greater internal uncertainty exacerbates the issue of controllability over outcomes and therefore is associated with a lower likelihood of using incentives, even after controlling for delegation.

Internal uncertainty is also associated with monitoring, negatively, implying that the cost of monitoring increases with internal uncertainty. No significant association is found between internal uncertainty and ILM, possibly because ILM serves multiple functions that are related in opposite ways to internal uncertainty.

Turning now to an analysis of complementarities and substitutions among practices, we find that delegation is generally positively associated with monitoring and ILM, suggesting that these practices complement delegation of decision-making. This is consistent with the monitoring-intensity principle (monitoring workers to insure that they use their information and decision-making adequately). Regarding incentives, we find again differences that depend on the level at which the incentives operate. Individual and group-level incentives are not associated significantly with either delegation or monitoring, but are complementary with ILM. The results for profit sharing incentives show a different picture. In contrast, profit sharing has a significant positive association with team delegation, suggesting complementarity (as in Table 2b). Profit sharing is significantly and negatively associated with both monitoring and ILM, suggesting that after controlling for uncertainty, both practices substitute for incentives. Taken together, the results for profit sharing suggest that the benefits of increasing team delegation in response to greater internal uncertainty and complementing it with profit sharing are limited by the growing costs of monitoring, so that the net result is that, in response to greater internal uncertainty, firms are less likely to use profit sharing, monitoring and ILM practices.

In order to insure the robustness of the results we performed additional analyses.[25] First, we reran the analysis underlying Tables 1, 2a and 2b using the reduced sample (due to missing observations on the monitoring and wage variables) of Tables 3a and 3b, and found the results to be very similar. Second, we replicated the analysis for model D, reversing the specifications for ILM and monitoring, and again found the results to be very similar.[26]

V. Conclusions

Organization design may be viewed as a set of responses to informational issues faced by the firm and its workers, aimed at ameliorating agency and technical problems that cause workers to apply lower and less apt effort than it is in the interest of the firm. In this paper we have validated empirically the idea that uncertainty created by these informational issues is not one-dimensional. Two dimensions of uncertainty – external uncertainty that stems from external market factors and internal uncertainty associated with the task environment faced by workers and managers – have distinct and often contradictory impact on firms' decisions about how to design their workplace using incentive pay, delegation, monitoring and internal labor market practices. Our results confirm the arguments on uncertainty presented by Baker and Jorgensen (2003) and the idea that incentive pay should not be seen as a single response to the firm's type of task environment but as part of a system of practices including delegation, suggested by Prendergast (2002a), as well as monitoring and internal labor markets.

Our results on the relationship between risk and delegation and between delegation and incentives are consistent with the findings of Foss and Laursen (2005) and DeVaro and Kurtulus (2006), who employ different measures of risk and incentives (and different datasets). The analysis in the present paper additionally enables us to conclude that these relationships hold for different levels of incentive plans - individual, group and firm. Moreover, our analyses, which distinguish between different sources of uncertainty and integrate multiple

[25] The results for the robustness checks are available upon request.

[26] For individual-level plans, the alternative specification yields a significant negative association (previously insignificant) between monitoring and delegation, suggesting that a greater degree of delegation is accompanied by less monitoring of workers, as well as a significant positive association (previously insignificant) between monitoring and ILM, suggesting the possibility that firms uses them in a complementary fashion when deciding to rely on individual-level incentives.

elements of organization design at different levels, help clarify the risk-incentives tradeoff issue and reach the following conclusions. When risk (associated with external uncertainty or internal uncertainty) reduces *workers*' control over their outcomes, then there is evidence of a risk-incentives trade-off for incentive plans with weak line of sight such as profit sharing plans. When risk arising from the task environment (internal uncertainty) is responsible chiefly for both asymmetry of information between management and workers and limited information for *management*, delegation of decision-making to workers is the best response, with individual and group-level incentives following.[27] We also find significant positive associations between delegation and monitoring and ILM practices suggesting complementarities between these practices. Relationships between ILM practices, monitoring and incentives seem to depend on the type of incentives plan.

This paper has presented a broader view of organization design than that available in previous empirical work and validated empirically, using a uniquely rich dataset, the complementary and substitutable roles played by various elements of organization design, and how different combinations of these elements are selected by firms in relationship to different types and levels of uncertainty. The paper has also shown that the distinction between different levels – individual, group and firm – enables a better understanding of organization design than a consideration of the firm as a single entity. Our empirical results are generally substantial in magnitude and statistically significant, suggesting that the relationships that we postulated seem to be present and meaningful in many of our sample of hundreds of firms.

The findings of this paper answer several questions concerning the relationship between uncertainty and organization design, and the relations among different components of organization design. Several related issues that were broached but not addressed in this paper merit future research. One issue that merits investigation is the relationship of the task environment – the source of internal uncertainty – to production technology, business strategy and other factors that may be chosen by the firm or at least be under its influence. Another

[27] This is the instrumental role of delegation. Unlike DeVaro and Kurtulus (2006) and Foss and Laursen (2005), we find strong support for it for individual and group incentives plans. Also, contrary to DeVaro and Kurtulus, we find evidence of endogeneity in the choice of organization design practices. We find that the correlations between the residuals of each practice including incentives and delegation are highly significant (results available upon request).

topic concerns the relative costs and benefits of different elements of organization design and the complementarity and substitution relations among them. Finally, there is little empirical evidence and only limited theoretical understanding of the effects on firm performance of the choice of organization design.[28] A better understanding of these issues has not only scholarly value by throwing light on important questions of organization, but could improve the complex task of organization design by helping decision-makers target better the various elements of organization design according to their relative costs and benefits and the relationships among them, and ultimately their contribution to organizational performance.

[28] Bresnahan, Brynjolfsson and Hitt (2002) provide a good starting point for such an inquiry.

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Figure 1. The Relationships among Task Environment, AM and TA Problems, Incentives and Delegation of Decision-Making

	Cause	***Proximate consequence***	***Ensuing problems***	***Organization design responses to alleviate the problems***
A	Difficult task environment (*Internal Uncertainty*)	Asymmetric information between workers and supervisors	Workers able to pursue their objectives at the organization's expense – AM problems	Incentives linked to outcomes over which workers have influence, and other practices
B	Difficult task environment (*Internal Uncertainty*)	Incomplete information *for workers* creates *uncontrollable* risk at the shop floor regarding the outcomes of their actions	Difficulty making informed decisions by workers – TA problems Incentives linked to *shop floor* outcomes will impose on workers risk over which they have only partial or no control	Relevant incentives will be used less
C	Risk–uncertainty (*External Uncertainty*)	Incomplete information *for workers* creates uncontrollable risk regarding *the firm*'s outcomes	Incentives linked to *firm level* outcomes will impose on workers risk over which they have only partial or no control	Relevant incentives will be used less
D	Difficult task environment (*Internal Uncertainty*)	Incomplete information *for supervisors*	Difficulty making informed decisions by supervisors – TA problems	Delegation of decision-making to shop-floor workers
E	Delegation of decision-making to workers	Asymmetric information between workers and supervisors	Workers able to pursue their objectives at the organization's expense – AM problems	Incentives linked to outcomes over which workers have influence, and other practices

Figure 2. Empirical Relationships between Uncertainty, Delegation, Incentives and Monitoring and ILM

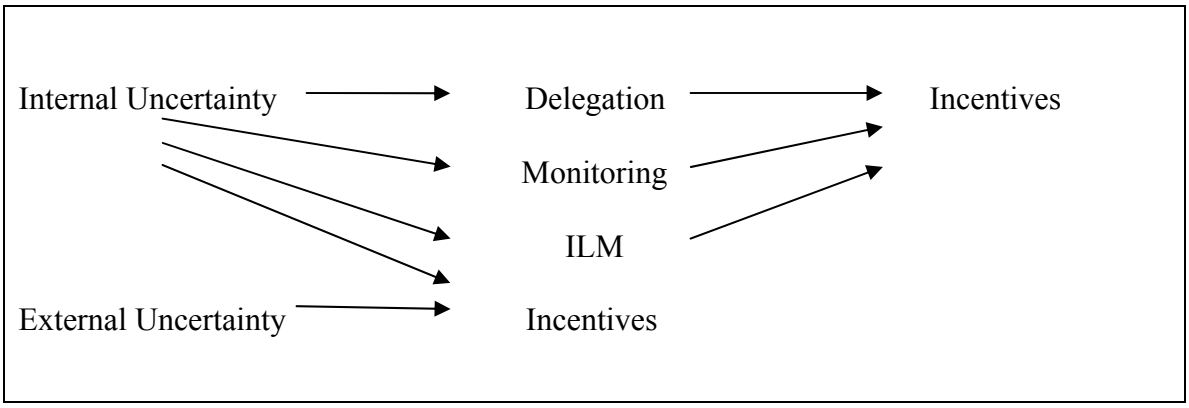

Table 1: Uncertainty and Incentives[1]

	Model A		
	Individual Incentives	**Group/Firm Level Incentives**	
		Group Bonus	**Profit Sharing**
External Uncertainty	-0.009	-0.015	-0.021*
	(0.012)	*(0.011)*	*(0.013)*
Internal Uncertainty	0.031***	0.024***	0.000
	(0.009)	*(0.009)*	*(0.010)*
R^2	0.05	0.04	0.06
N	640	640	640

Notes:
1- Also includes controls for industry (1-digit SIC), union, the log of firm size, firm age, and capital-labor ratio. Robust standard errors are in parentheses. ***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level.

Table 2a: Uncertainty, Delegation *cum* Participation and Individual Incentives[1]

	Model B		*Model C*	
	Delegation[2]	**Incentives**	**Delegation[2]**	**Incentives**
Delegation		0.110***		0.066
		(0.036)		*(0.043)*
Internal Uncertainty	0.093***		0.090***	0.018*
	(0.016)		*(0.016)*	*(0.010)*
Chi^2	211.11	9.19	210.41	12.25
(p-value)	*(0.000)*	*(0.002)*	*(0.002)*	*(0.000)*
N	640	640	640	640

Notes:
1-Also includes controls for industry (1-digit SIC), union, the log of firm size, firm age, and capital-labor ratio. Robust standard errors in parentheses.
2-Also includes a participation index that measures employee participation in decision-making on various issues. See text for details.
***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level.

Table 2b: Uncertainty, Team Delegation and Group/Firm Incentives[1]

	Model B		*Model C*	
	Team Delegation[2]	**Incentives**	**Team Delegation[2]**	**Incentives**
		Group Bonus		
Team Delegation		0.506***		0.488***
		(0.102)		*(0.125)*
Internal Uncertainty	0.036***		0.036***	0.001
	(0.007)		*(0.007)*	*(0.010)*
Chi^2	91.54	24.57	91.42	24.03
(p-value)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
N	640	640	640	640
		Profit Sharing		
Team Delegation		0.555***		0.806***
		(0.119)		*(0.151)*
Internal Uncertainty	0.031***		0.036***	-0.029**
	(0.007)		*(0.007)*	*(0.012)*
Chi^2	92.22	21.81	94.06	29.21
(p-value)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
N	640	640	640	640

Notes:
1-Also includes external uncertainty and controls for industry (1-digit SIC), union, the log of firm size, firm age, and capital-labor ratio. Robust standard errors in parentheses.
2-Also includes a participation index that measures employee participation in decision-making on various issues. See text for details.
***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level.

Table 3a: Uncertainty, Individual Incentives, Monitoring and Internal Labor Market[1]

	Model D			
	Delegation[2]	**Monitoring[3]**	**Internal Labor Market[4]**	**Individual Incentives**
External Uncertainty	-	-	-	0.019
				(0.016)
Internal Uncertainty	0.098***	-0.115***	0.018	0.001
	(0.027)	*(0.028)*	*(0.050)*	*(0.020)*
Delegation	-	0.029	0.749***	-0.128
		(0.110)	*(0.213)*	*(0.115)*
Monitoring	-	-	0.323	0.003
			(0.237)	*(0.126)*
Internal Labor Market	-	-	-	0.347***
				(0.119)
Chi[2]	77.66	23.60	43.08	20.89
(p-value)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*

Notes:
1-Also includes controls for industry (1-digit SIC), union, the log of firm size, firm age, and capital-labor ratio and the log of average wage. The number of observations is 305. Robust standard errors in parentheses. ***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level.
2-Also includes a participation index that measures employee participation in decision-making in various issues. See the text for details.
3-Also includes the proportion of employees per supervisor. See the text for details.
4-Also includes a dummy indicating the extent to which employees participate in rules related to training and development. See text for details.

Table 3b: Uncertainty, Group/Firm-Level Incentives, Monitoring and Internal Labor Market[1]

	Model D			
	Team Delegation[2]	**Monitoring[3]**	**Internal Labor Market[4]**	**Group Bonus**
External Uncertainty	-	-	-	0.008
				(0.017)
Internal Uncertainty	0.033***	-0.175***	-0.001	0.004
	(0.011)	*(0.033)*	*(0.056)*	*(0.024)*
Team Delegation	-	1.583***	1.992***	-0.011
		(0.470)	*(0.678)*	*(0.323)*
Monitoring	-	-	0.008	0.053
			(0.252)	*(0.133)*
Internal Labor Market	-	-	-	0.311***
				(0.072)
Chi2	27.99	29.64	34.45	37.75
(p-value)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
	Team Delegation[2]	**Monitoring[3]**	**Internal Labor Market[4]**	**Profit Sharing**
External Uncertainty	-	-	-	-0.035*
				(0.019)
Internal Uncertainty	0.032***	-0.169***	0.004	-0.099***
	(0.011)	*(0.032)*	*(0.055)*	*(0.030)*
Team Delegation	-	1.441***	1.864***	1.968***
		(0.464)	*(0.686)*	*(0.399)*
Monitoring	-	-	0.112	-0.359**
			(0.251)	*(0.150)*
Internal Labor Market	-	-	-	-0.180**
				(0.084)
Chi2	34.65	27.26	33.94	42.09
(p-value)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*

Notes:
1-Also includes controls for industry (1-digit SIC), union, the log of firm size, firm age, and capital-labor ratio and the log of average wage. The number of observations is 305. Robust standard errors in parentheses. ***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level.
2-Also includes a participation index that measures employee participation in decision-making in various issues. See the text for details.
3-Also includes the proportion of employees per supervisor. See text for details.
4-Also includes a dummy indicating the extent to which employees participate in rules related to training and development. See text for details.

Appendix Table A1: Variable Definitions, Sources and Summary Statistics

Variable Name	*Variable Definition and Source*	*Mean (Std. Err.)*
Organization design variables		
Individual Incentives	Existence of an individual incentives plan. 0 = no, 1 = yes; from survey.	0.336
Group/firm-level incentives	Existence of cash or deferred profit sharing plan. 0 = no, 1 = yes; from survey.	0.364
	Existence of group bonus plan. 0 = no, 1 = yes; from survey.	0.232
Delegation - participation	The extent to which core employees participate in an employee involvement program; 1-5 scale, 1 = not at all, 5 = extreme; from survey.	3.01 (0.039)
Delegation - control	The extent to which core employees have control over how their work is done; 1-5 scale, 1 = not at all, 5 = extreme; from survey.	3.39 (0.036)
Delegation - team work	Existence of self-managing work teams. 0 = no, 1=yes; from survey.	0.232 (0.016)
Monitoring	The extent to which core employees' work is monitored by their supervisors; 1-5 scale, 1 = not at all, 5 = extreme; from survey.	3.44 (0.041)
Internal labor market (ILM)	Sum of promotion from within, employment security, on-the-job training, and training in team building skills (all dichotomous variables). 0-4; from survey	2.296 (0.043)
Uncertainty variables		
Complexity	The extent to which core employees' work tasks are complex; 1-5 scale, 1 = not at all, 5 = extreme; from survey.	2.92 (0.039)
Variability	The extent to which core employees' work tasks are variable; 1-5 scale, 1 = not at all, 5 = extreme; from survey.	3.21 (0.039)
Routine	The extent to which core employee's work activities are routine; 1-5 scale, 1 = not at all, 5 = extreme; from survey.	3.45 (0.034)
Internal uncertainty	The sum of complexity, variability and reversed-routine scales, 3=not at all, 15= extreme; from survey	8.67 (0.084)
External uncertainty	Logarithm of standard deviation of net income; based on 5 years of net income in 3-digit SIC industries, 1990-1994; from COMPUSTAT.	4.99 (0.072)

Appendix Table A1: Variable Definitions, Sources and Summary Statistics - Continued

Variable Name	*Variable Definition and Source*	*Mean (Std. Err.)*
Firm characteristics		
Firm size	Total number of employees; from Minnesota Department of Economic Security.	240 (55.26)
Firm age	Years in business since establishment; from survey	33.11 (1.045)
Unionization	Firm's unionization status; 0 = non-union, 1 = union; from survey.	0.174
Capital-labor ratio	Log of capital-labor ratio (in $1000's per worker) in 3-digit SIC industries; from COMPUSTAT	4.68 (0.044)
Industry		
	Mining, Construction	2.8
	Manufacturing	36.7
	Transportation	2.5
	Trade (Wholesale, Retail)	43.6
	Finance, Insurance	4.2
	Services	10.1

Appendix Table B1: Uncertainty, Delegation *cum* Control and Individual Incentives[1]

	Model A		*Model B*	
	Delegation[2]	**Incentives**	**Delegation[2]**	**Incentives**
Delegation-*Control*		0.138***		0.062
		(0.044)		*(0.061)*
Internal Uncertainty	0.117***		0.114***	0.018
	(0.016)		*(0.016)*	*(0.012)*
Chi2	143.14	9.80	140.63	10.90
(p-value)	*(0.000)*	*(0.001)*	*(0.000)*	*(0.004)*
N	640	640	640	640

Notes:
1-Also includes controls for industry (1-digit SIC), union, the log of firm size, firm age, and capital-labor ratio. Robust standard errors in parentheses.
2-Also includes a participation index that measures employee participation in decision-making in various issues. See the text for details.
***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level.

Appendix Table B2: Uncertainty, Individual Incentives, Delegation *cum* Control, Monitoring and Internal Labor Market[1]

	Delegation[2]	Monitoring[3]	Internal Labor Market[4]	Individual Incentives
External Uncertainty	-	-	-	0.026
				(0.018)
Internal Uncertainty	0.122***	-0.170***	-0.031	0.017
	(0.025)	*(0.033)*	*(0.066)*	*(0.026)*
Delegation - *Control*	-	0.405***	0.790***	-0.169
		(0.142)	*(0.279)*	*(0.114)*
Monitoring	-	-	0.037	0.059
			(0.260)	*(0.135)*
Internal Labor Market	-	-	-	0.325***
				(0.080)
Chi2	61.02	31.46	42.24	23.03
(p-value)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*

Notes:
1-Also includes controls for industry (1-digit SIC), union, the log of firm size, firm age, and capital-labor ratio and the log of average wage. The number of observations is 305. Robust standard errors in parentheses. ***=significant at the 1% level, **=significant at the 5% level, *=significant at the 10% level.
2-Also includes a participation index that measures employee participation in decision-making in various issues. See the text for details.
3-Also includes the proportion of employees per supervisor. See the text for details.
4-Also includes a dummy indicating the extent to which employees participate in rules related to training and development. See the text for details.